

## OBSERVATIONS

## Is the Frequency of Ketoacidosis at Onset of Type 1 Diabetes a Child Health Indicator That is Related to Income Inequality?

A recently published systematic review identifies a number of patient-, family-, physician-, and disease-related factors that account for the presence of diabetic ketoacidosis (DKA) at the onset of disease in children and youth (1). We propose a unifying hypothesis for these factors that the frequency of DKA at disease onset may be related to income inequality.

Income inequality is defined as the difference in average incomes between a nation's highest and lowest income earners (2). Wilkinson and Pickett (2) have provided compelling evidence that income inequality is a major determinant of health and social outcomes in the world's most advanced countries. Health indicators such as infant mortality and low birth weight have been found to be less favorable in nations where income inequality is greater (2). We propose that frequency of DKA at onset of type 1 diabetes may be an additional valuable indicator of child health outcomes that is also influenced by income inequality.

We performed an environmental scan to obtain frequencies of DKA at onset of type 1 diabetes published since 1990. We obtained income inequality data on all nations for which DKA frequencies were reported using two measures: 1) the 20:20 quintile ratio (how wealthy the most affluent 20% of the population is compared with the poorest 20%) (3) and 2) the Gini coefficient (a value between 0 and 100, where 0 expresses full equality and 100

represents maximal inequality) (4,5). We tested the relationship between income inequality and frequency of DKA at onset using simple linear regression analyses. We also collected mean HbA<sub>1c</sub> levels in children with type 1 diabetes and similarly assessed the relationship between income inequality and mean HbA<sub>1c</sub> levels.

Our preliminary analysis suggests that in the world's wealthiest nations, the frequency of DKA at type 1 diabetes onset in children ranges from 16–54.2% and is significantly related to income inequality ( $r = 0.629$ ,  $P < 0.001$ ). As poorer nations are added to the analysis, the significance of this relationship is lost. There is no relationship between mean HbA<sub>1c</sub> levels and income inequality.

Wilkinson and Pickett suggest that income inequality exaggerates the impact of social status and reduces the quality of social relationships and levels of trust between members of society (2). We propose that the resulting social division leads to loss of social security nets and ultimately, poorer health outcomes across all income levels. Our findings suggest that income inequality may explain a substantial amount of the variability in frequency of DKA at type 1 diabetes onset among children living in wealthy nations. When poorer nations are included in the analysis, progressively less of the variability can be attributed to income inequality. This can be explained by the dilution of income inequality by severe levels of poverty: when a nation is so poor that access to food, water, insulin, and medical supplies is jeopardized, the level of income inequality becomes less relevant. Despite the lack of available, high-quality, and standardized data with which to perform analyses, our findings support policy initiatives aimed at reducing income inequality and preventing DKA.

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Additional references for income inequality and frequency of DKA at type 1 diabetes onset data are available upon request.

### References

1. Usher-Smith JA, Thompson MJ, Sharp SJ, Walter FM. Factors associated with the presence of diabetic ketoacidosis at diagnosis of diabetes in children and young adults: a systematic review. *BMJ* 2011;343:d4092
2. Wilkinson R, Pickett K. *The Spirit Level: Why Equality is Better for Everyone*. London, Penguin Books, 2010
3. Human Development Report Office. Human Development Report: inequality in income or expenditure [PDF online], 2007/08. Available from [http://hdr.undp.org/en/media/HDR\\_20072008\\_EN\\_Indicator\\_tables.pdf](http://hdr.undp.org/en/media/HDR_20072008_EN_Indicator_tables.pdf). Accessed 15 June 2011
4. Human Development Report Office. Human Development Report: inequality-adjusted human development index [PDF online], 2010. Available from [http://hdr.undp.org/en/media/HDR\\_2010\\_EN\\_Tables\\_reprint.pdf](http://hdr.undp.org/en/media/HDR_2010_EN_Tables_reprint.pdf). Accessed 15 June 2011
5. The World Factbook. Distribution of family income - Gini index, updated 2011 [article online], 2011. Available from <https://www.cia.gov/library/publications/the-world-factbook/fields/2172.html>. Accessed 15 June 2011